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[54]	ZOOM LENS CAPABLE OF
	ACCOMPLISHING
	MACRO-PHOTOGRAPHY

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[22] Filed: Jun. 3, 1985

[30] Foreign Application Priority Data

[56] References Cited

U.S. PATENT DOCUMENTS

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Attorney, Agent, or Firm—Shapiro and Shapiro

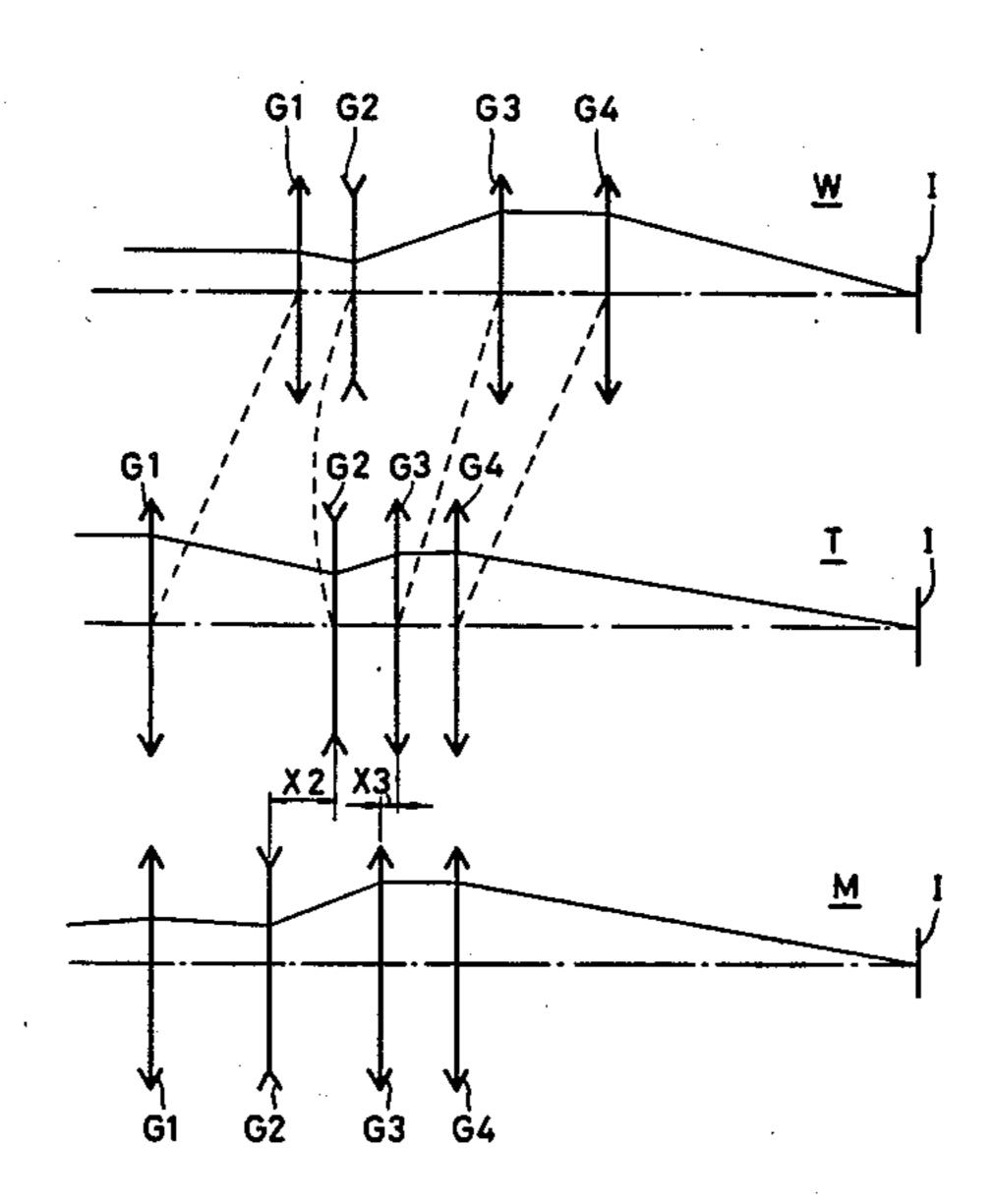
[57] ABSTRACT

A zoom lens has, in succession from the object side, a first lens group of positive refractive power, a second lens group of negative refractive power and a fourth lens group of positive refractive power. The first lens group, the third lens group and the fourth lens group are movable toward the object side for a magnification change from the wide angle end to the telephoto end. The focusing up to a short distance object is made possible by moving the second lens group along the optic axis from the position of its telephoto end toward the object side and moving the third lens group along the optic axis from the position of its telephoto end. The zoom lens satisfies the following condition:

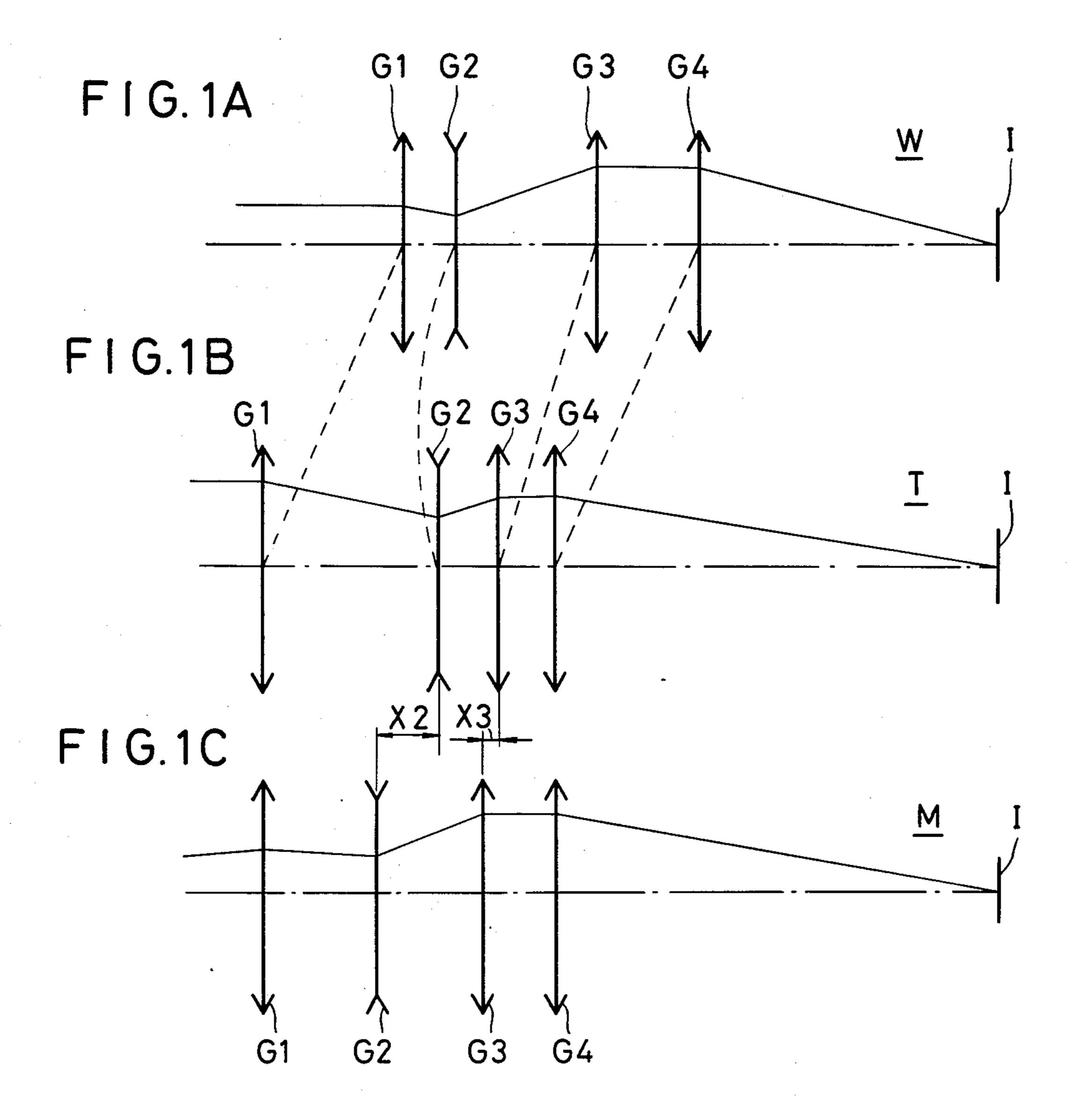
 $-0.5 < \chi 3/\chi 2 < 0.5$

where χ^2 is the amount of movement of the second lens group from the telephoto end toward the object side for short distance focusing and χ^3 is the amount of movement of the third lens group from the telephoto end toward the object side for short distance focusing.

7 Claims, 8 Drawing Sheets



Sep. 13, 1988



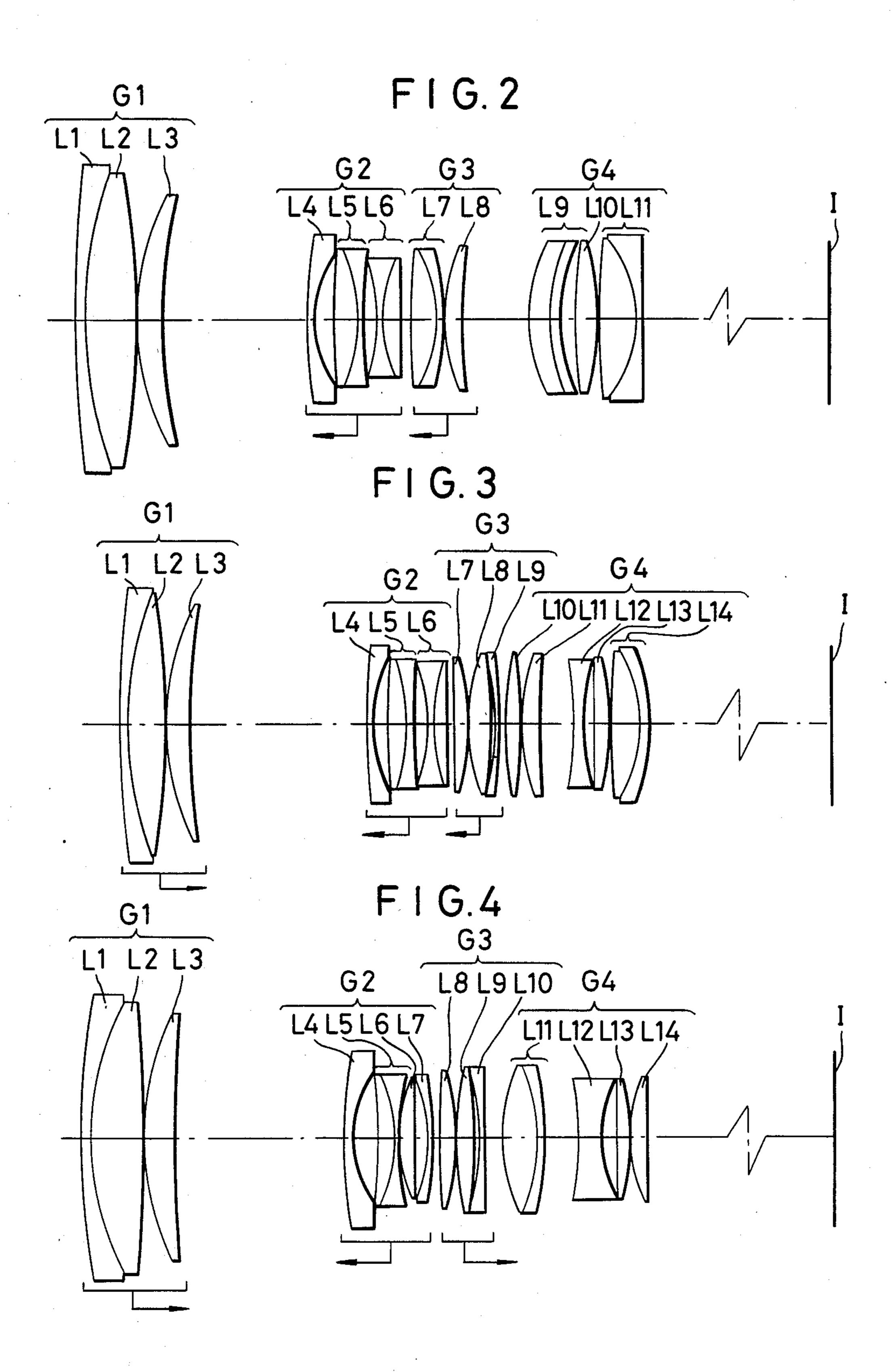
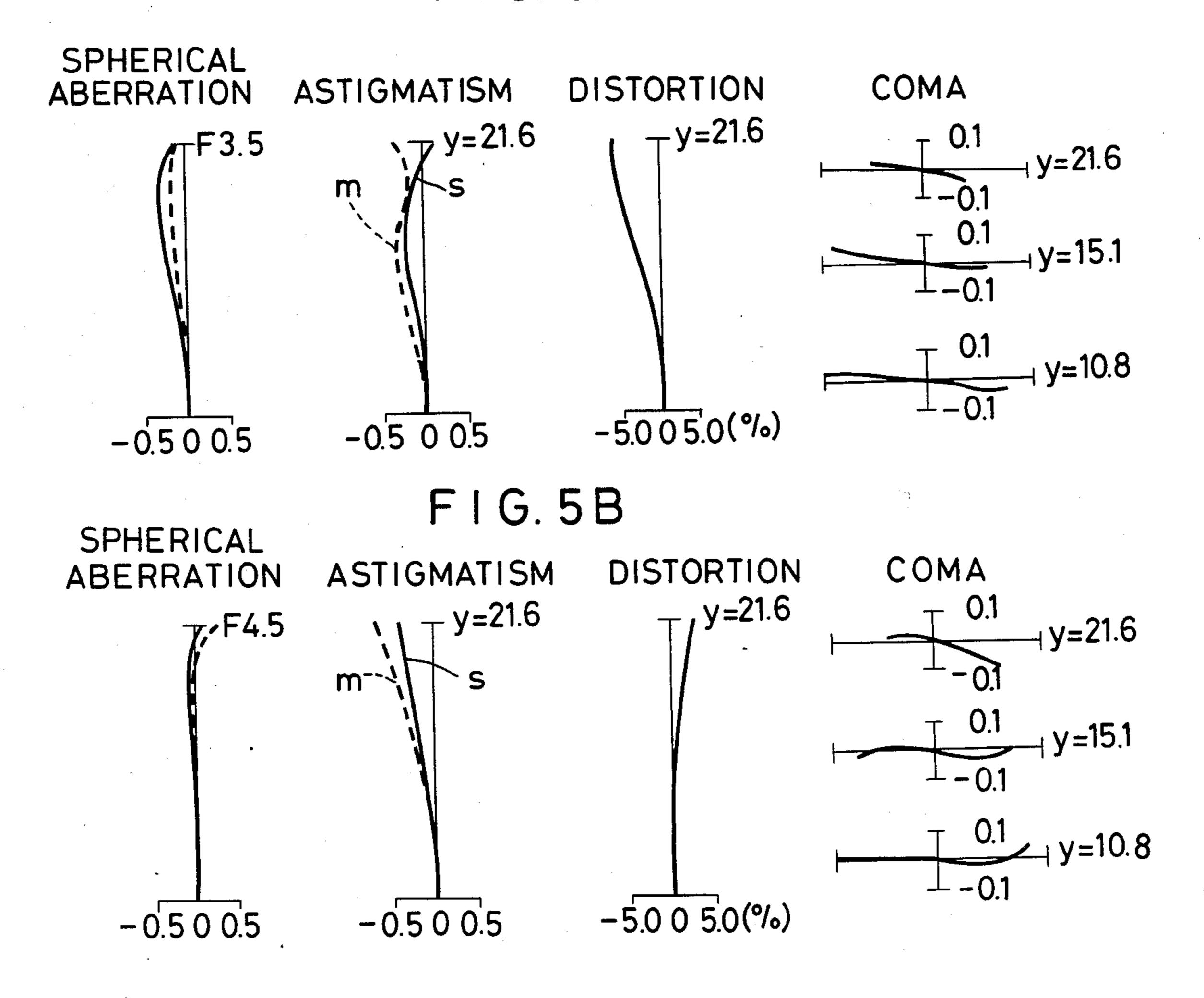


FIG. 5A



F 1 G. 5 C

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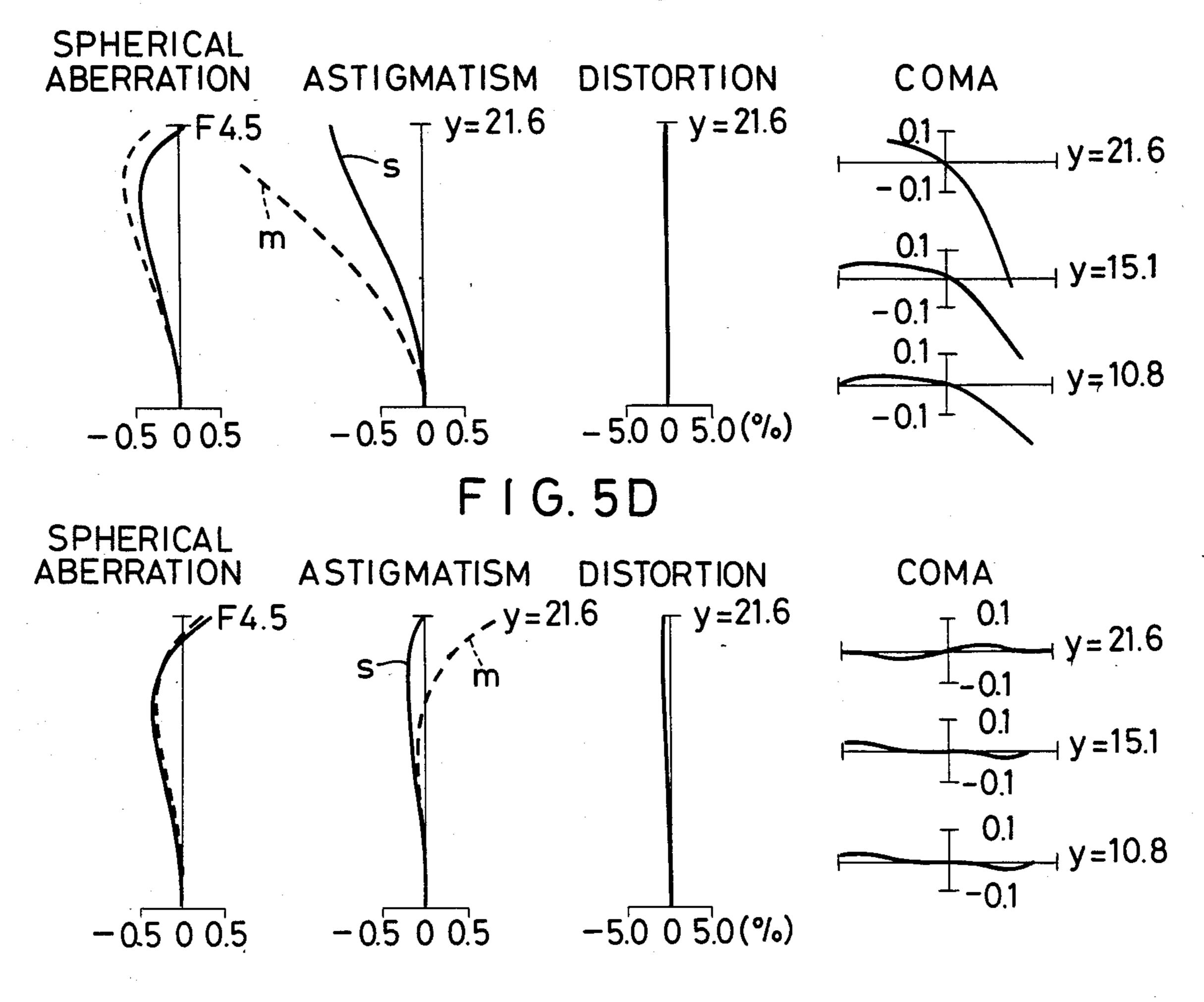


FIG.6A

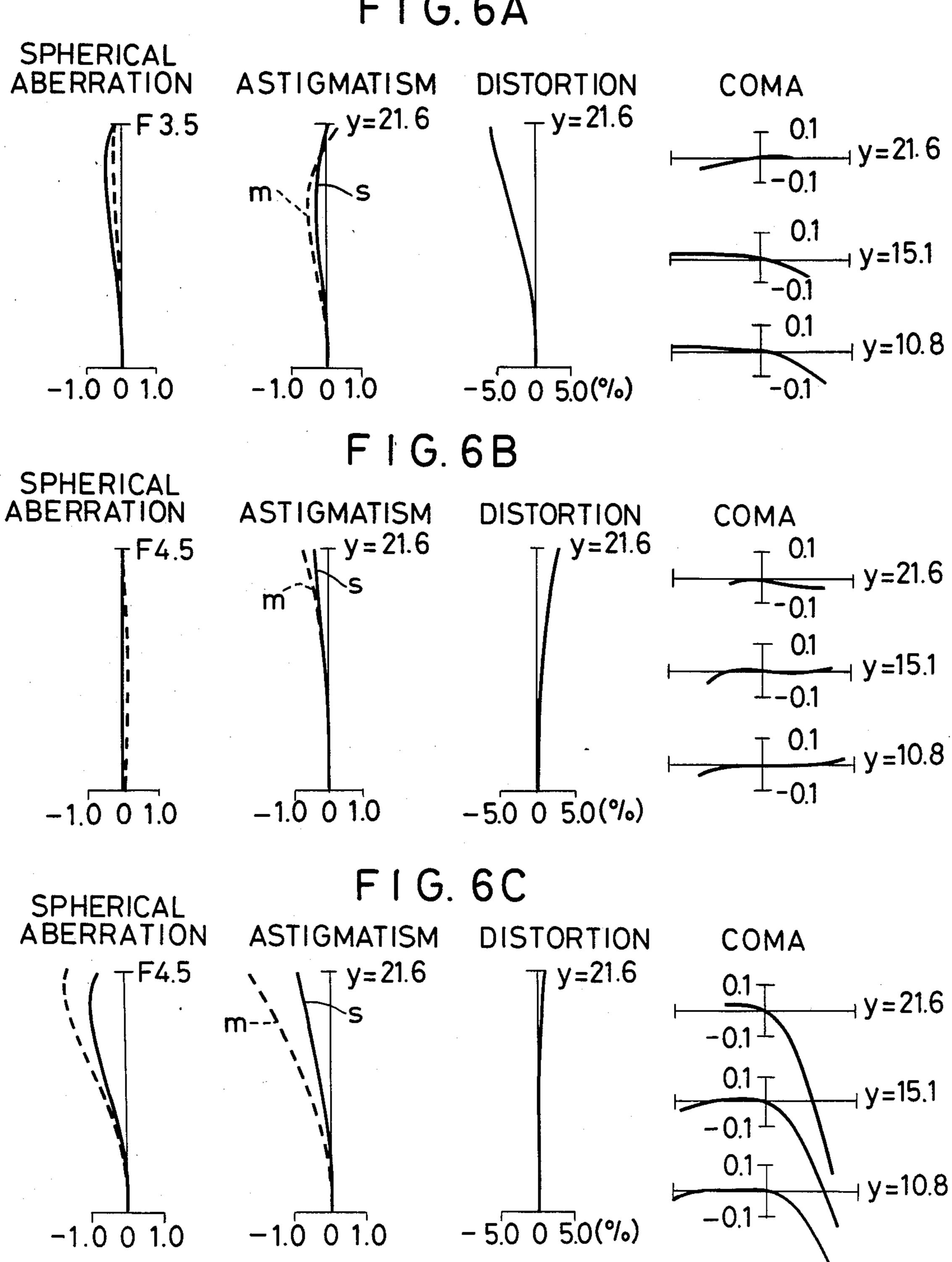


FIG. 6D

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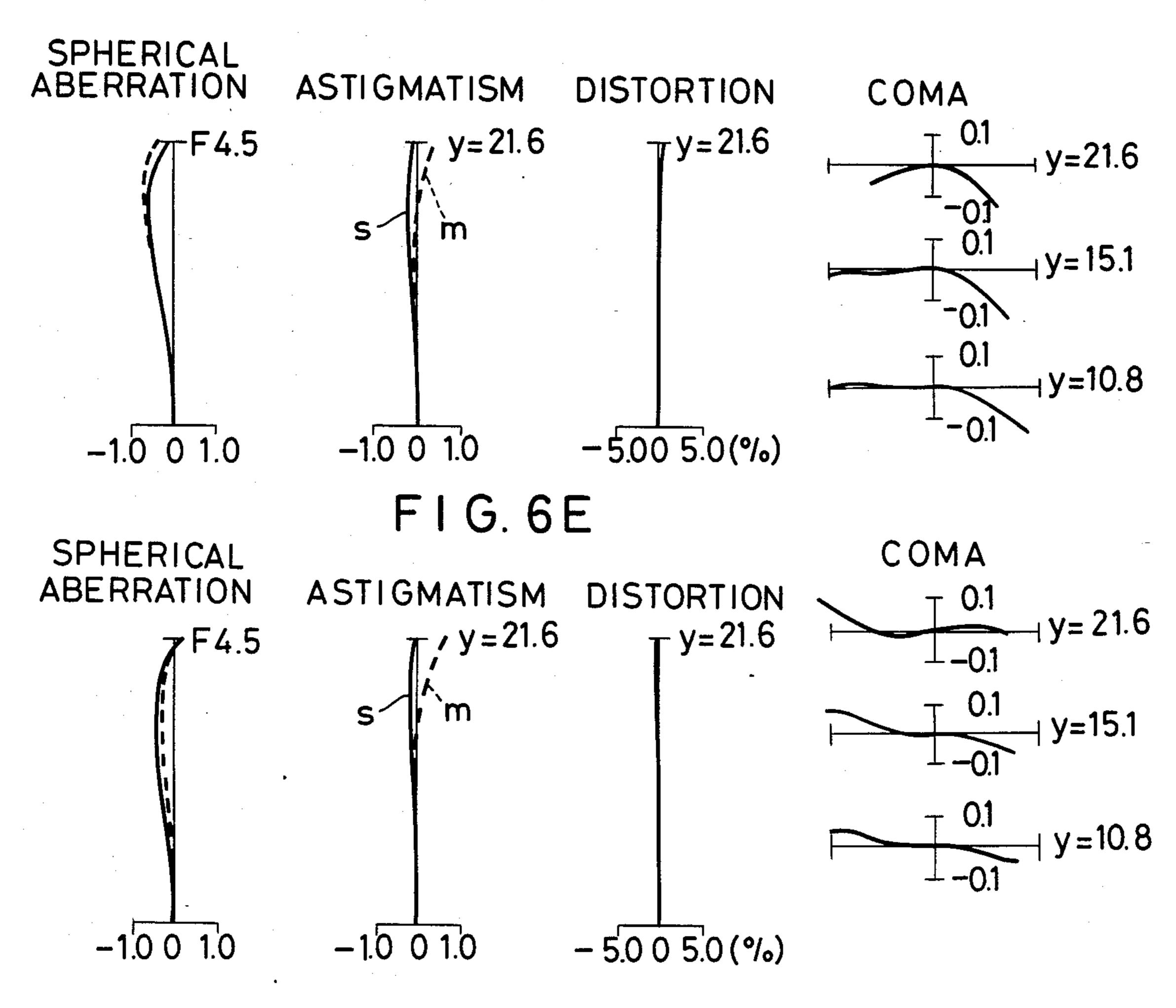
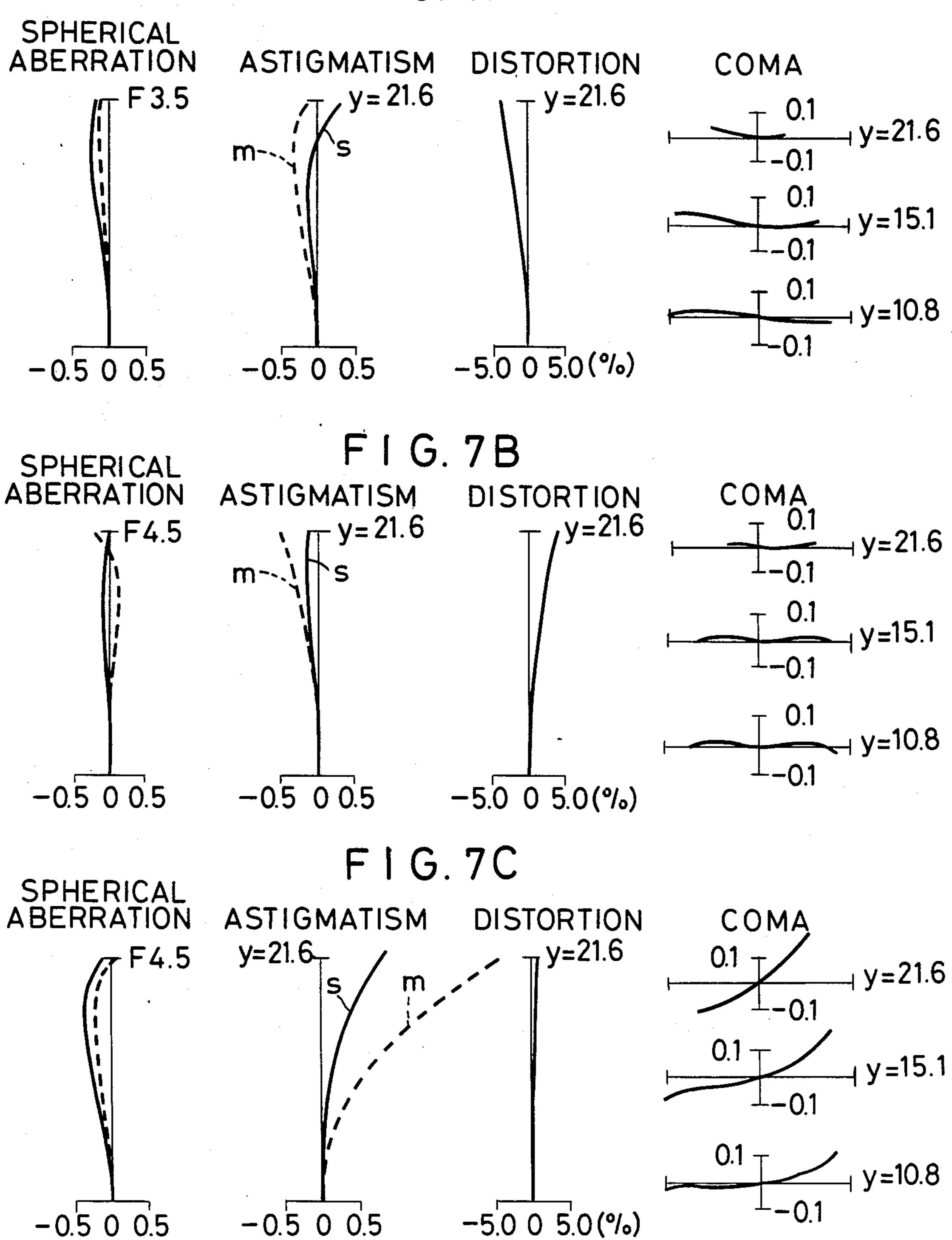
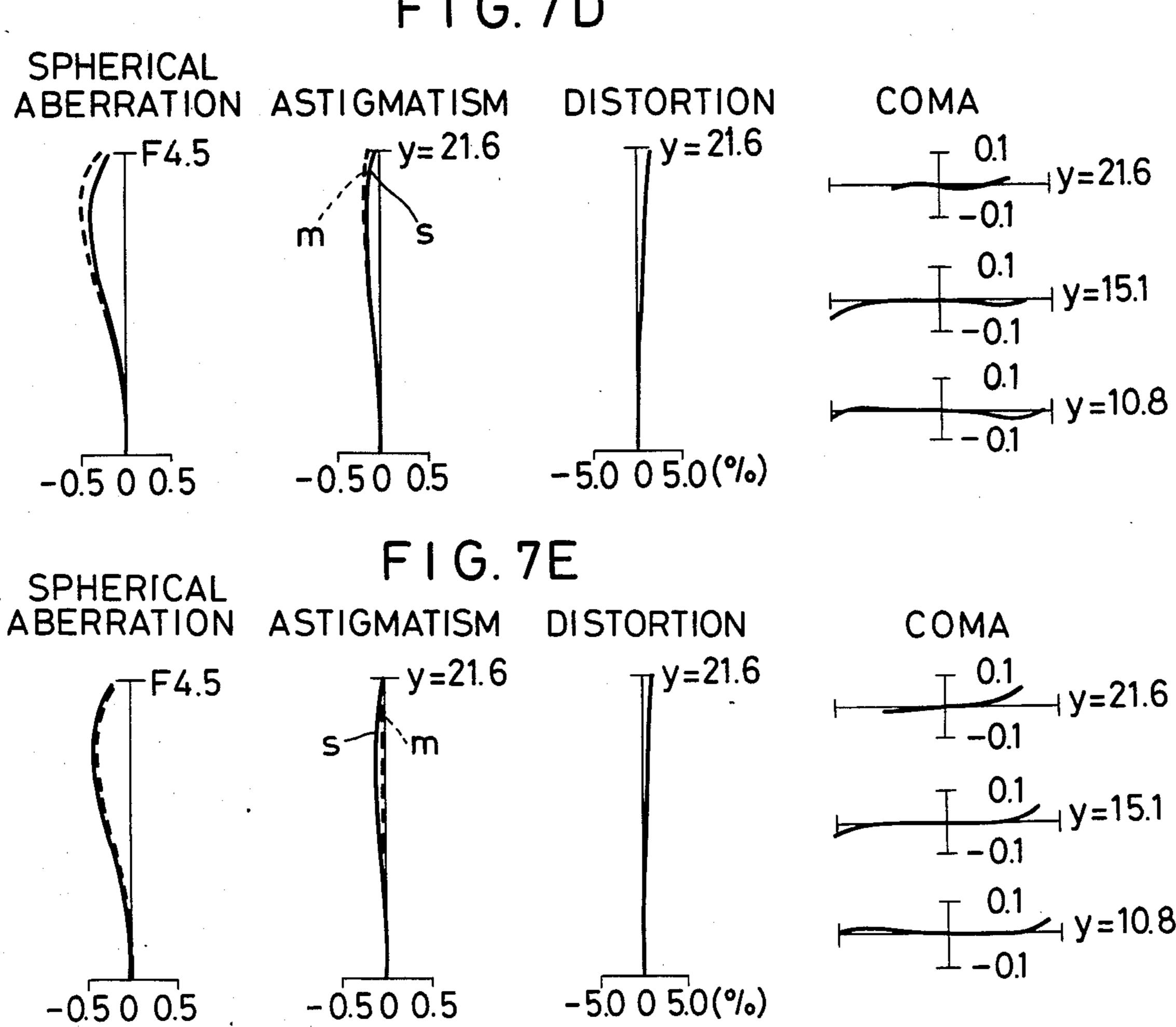


FIG. 7A



Sheet 8 of 8

F I G. 7D



ZOOM LENS CAPABLE OF ACCOMPLISHING MACRO-PHOTOGRAPHY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a zoom lens capable of accomplishing macro-photography.

2. Description of the Prior Art

Numerous zoom lenses including a wide angle of view and having a relatively wide magnification change area have recently been proposed, but most of them have been long in the shortest photographing distance as compared with single focal length objective lenses having the same degree of focal length, and the shortest photographing distance and the maximum photographing magnification have still been insufficient in such zoom lenses. In order to overcome this disadvantage, use has been made of a method of shortening the photo- 20 graphing distance by moving the lens groups along the optic axis other than the lens group moved from the ordinary focusing, that is, the so-called macro-photography system. However, in the conventional macrophotography system, the shorter the photographing 25 distance, the more substantial the occurrence of aberrations and therefore, in macro-photography, the imaging performance is deteriorated and however excellent in the imaging performance in the infinity photographing stage, it has been difficult to maintain the good performance in a short distance as well.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a zoom lens which is capable of accomplishing photo- 35 graphing up to a very short distance and moreover can maintain an excellent imaging performance even in macro-photography.

To achieve the above object, the zoom lens capable of accomplishing macro-photography according to the 40 present invention has, in succession from the object side, a first lens group of positive refractive power, a second lens group of negative refractive power, a third lens group of positive refractive power and a fourth lens group of positive refractive power, the first lens group, 45 the third lens group and the fourth lens group being movable toward the object side for a magnification change from the wide angle end to the telephoto end, and in such zoom lens, the focusing up to a short distance object is made possible by moving the second lens 50 group along the optic axis from the position of its telephoto end toward the object side and moving the third lens group along the optic axis from the position of its telephoto end and the following condition is satisfied:

$-0.5 < \chi_3/\chi_2 < 0.5$

where χ_2 is the amount of movement of the second lens group from the telephoto end toward the object side for short distance focusing and χ_3 is the amount of move- 60 ment of the third lens group from the telephoto end toward the object side for short distance focusing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B and 1C are basic construction views 65 showing the construction of the zoom lens according to the present invention and the construction for macrophotography.

FIG. 2 shows the lens construction of a first embodiment of the present invention at the telephoto end thereof.

FIG. 3 shows the lens construction of a second embodiment of the present invention at the telephoto end thereof.

FIG. 4 shows the construction of a third embodiment of the present invention at the telephoto end thereof.

FIG. 5A shows the various aberrations at the wide angle end of the first embodiment.

FIG. 5B shows the various aberrations at the telephoto end of the first embodiment.

FIG. 5C shows the various aberrations for the comparison with the aberrations in the first embodiment during macro-photography.

FIG. 5D shows the various aberrations in the first embodiment during macro-photography.

FIG. 6A shows the various aberrations at the wide angle end of the second embodiment.

FIG. 6B shows the various aberrations at the telephoto end of the second embodiment.

FIGS. 6C and 6D show the various aberrations for the comparison with the aberrations in the second embodiment during macro-photography.

FIG. 6E shows the various aberrations in the second embodiment during macro-photography.

FIG. 7A shows the various aberrations at the wide angle end of the third embodiment.

FIG. 7B shows the various aberrations at the telephoto end of the third embodiment.

FIGS. 7C and 7D shows the various aberrations for the comparison with the aberrations in the third embodiment during macro-photography.

FIG. 7E shows the various aberrations in the third embodiment during macro-photography.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1A shows the arrangement of lens groups at the wide angle end, FIG. 1B shows the arrangement of lens groups at the telephoto end, and FIG. 1C shows the arrangement of lens groups in the macro-photography state from the telephoto end. In these Figures, broken lines indicate an example of the movement path of each group for magnification change, and I designates the image plane. As shown, the zoom lens of the present invention has, in succession from the object side, a first lens group G1 of positive refractive power, a second lens group G2 of negative refractive power, a third lens group G3 of positive refractive power and a fourth lens group G4 of positive refractive power. To accomplish macro-photography, with the position of each group at the telephoto end of the zoom lens as the reference, the second lens group G2 is moved toward the object side 55 and the third lens group G3 is moved toward the object side or the image side depending on the aberration fluctuation caused by the movement of the second lens group G2, and when the amount of movement of the second lens group G2 toward the object side is χ_2 and the amount of movement of the third lens group G3 toward the object side is χ_3 , $-0.5 < \chi_3/\chi_2 < 0.5$ is satisfied. Accordingly, the negative value in the above formula means that the third lens group G3 is moved toward the image side.

In the zoom lens of the present invention as described above, the second lens group G2 of negative refractive power at the telephoto end is moved toward the object side to thereby shorten the photographing distance and

enable macro-photography to be accomplished, but as the second lens group G2 is moved more toward the object side, that is, as the second lens group G2 is focused to a short distance object, the position of the principal light ray passing through the second lens 5 group G2 becomes more spaced apart from the optic axis and astigmatism is aggravated. Therefore, the present invention intends to correct the fluctuation of astigmatism by moving the third lens group G3 along the optic axis and varying the spacing between the third 10 lens group G3 and the fourth lens group G4 with the movement of the second lens group G2. The spacing between the third lens group G3 and the fourth lens group G4 is a substantially parallel light beam system during the infinity in-focus, and by varying this spacing, it is possible to vary only astigmatism and coma without greatly fluctuating spherical aberration. The optimum condition for achieving good correction of astigmatism is the aforementioned formula.

Moving the third lens group G3 toward the image 20 side is advantageous to increase the photographing magnification, but if this is done, the image side principal point of the entire lens system is moved toward the object side and the photographing distance when the magnification is made constant becomes great, and this 25 is disadvantageous to effect macro-photography. Also, astigmatism greatly fluctuates in the negative direction and it becomes difficult to well correct the fluctuation caused by the second lens group G2. If, conversely, the third lens group G3 is moved toward the object side, 30 the image side principal point of the entire lens system is moved toward the image side and the photographing distance for photographing at a predetermined magnification becomes small, but the photographing magnification is decreased. Also, in such case, astigmatism fluctu- 35 ates in the positive direction and it becomes difficult to sùfficiently correct the fluctuation caused by the second lens group G2. Accordingly, if the lower limit of the above-mentioned condition is departed from, it will become difficult to effect photography at a sufficiently 40 short photographing distance and moreover, astigmatism will be increased in the negative direction and it will become impossible to maintain a good imaging performance. On the other hand, if the upper limit of said condition is exceeded, the amount of movement of 45 the second lens group G2 will become great in order to gain the photographing magnification, and the first lens group G1 and the second lens group G2 will mechanically interfere with each other and thus, it will become difficult to increase the substantial photographing mag- 50 nification. Moreover, astigmatism will be increased in the positive direction and it will become difficult to maintain a good imaging performance.

In the macro-photographic system of the zoom lens according to the present invention, it is possible to cor- 55 rect the sine condition by moving the first lens group G1 along the optic axis during macro-photography. That is, during the macro-photography by the movement of the second lens group G2 and the third lens moving the first lens group G1 at the same time and thereby well correct not only astigmatism but also coma during macro-photography.

A first embodiment of the zoom lens capable of accomplishing macro-photography according to the pres- 65 ent invention enables macro-photography to be accomplished by moving the second lens group G2 of negative refractive power toward the object side and also mov-

ing the third lens group G3 of positive refractive power toward the object side as shown in FIG. 2. FIG. 2 shows the lens construction of the first embodiment at the telephoto end. In FIG. 2, letter I designates the image plane. In the first embodiment, the first lens group G1 is comprised, in succession from the object side, of a negative meniscus lens L1 convex toward the object side, a positive lens L2 cemented to the lens L1, and a positive meniscus lens L3 convex toward the object side, and the second lens group G2 is comprised, in succession from the object side, of a negative meniscus lens L4 convex toward the object side, a meniscus lens L5 comprising a positive lens and a negative lens cemented together and convex toward the object side, and a meniscus lens L6 comprising a negative lens and a positive lens cemented together and concave toward the object side. The third lens group G3 is comprised, in succession from the object side, of a lens L7 comprising a positive lens and a negative meniscus lens concave toward the object side, and a positive meniscus lens L8 convex toward the object side, and the fourth lens group G4 is comprised, in succession from the object side, of a lens L9 comprising a positive meniscus lens convex toward the object side and a negative meniscus lens convex toward the object side cemented together, a positive lens L10, and a lens L11 comprising a positive lens and a negative meniscus lens concave toward the object side cemented together.

A second embodiment of the present invention, as shown in FIG. 3 which shows the lens construction at the telephoto end, enables macro-photography to be accomplished by moving the second lens group G2 toward the object side and also moving the third lens group G3 toward the object side and further moving the first lens group G1 toward the image side.

In the second embodiment, the first lens group G1 is similar in construction to the first lens group G1 of the first embodiment with the exception that the lenses L1 and L2 are cemented together, and the second lens group G2 is of the same construction as that of the first embodiment. The third lens group G3 is comprised, in succession from the object side, of a positive meniscus lens L7 concave toward the object side, a positive lens L8 and a negative meniscus lens L9 concave toward the object side, and the fourth lens group G4 is comprised, in succession from the object side, of a positive lens L10, a positive meniscus lens L11 convex toward the object side, a negative lens L12, a positive meniscus lens L13 concave toward the object side, and a lens L14 comprising a positive lens and a negative meniscus lens concave toward the object side cemented together.

A third embodiment of the present invention, as shown in FIG. 4 which shows the lens construction at the telephoto end, enables macro-photography to be accomplished by moving the second lens group G2 toward the object side and moving the third lens group G3 toward the image side and further moving the first lens group G1 toward the image side.

In the third embodiment, the first lens group G1 is group G3, it is possible to control the sine condition by 60 similar in construction to the first lens group G1 of the second embodiment, and the second lens group G2 is comprised, in succession from the object side, of a positive meniscus lens L4 convex toward the object side, a lens L5 comprising a positive meniscus lens concave toward the object side and a negative lens cemented together, a positive meniscus lens L6 convex toward the object side, and a negative meniscus lens L7 concave toward the object side. The third lens group G3 is com-

TABLE 2-continued

(Second Embodiment)

Focal length: $f = 35 \sim 200$

F-number: 3.5~4.5

8.00

0.10

1.49782

82.28

40.51

64.18

-138.79

prised, in succession from the object side, of a positive lens L8, a positive lens L9 and a negative meniscus lens L10 concave toward the object side, and the fourth lens group G4 is comprised, in succession from the object side, of a lens L11 comprising a positive lens and a 5 negative meniscus lens concave toward the object side cemented together, a negative lens L12, a negative lens

1.50 1.80518 25.36

158.96

-	ve memseus.			•			3	-138.79	0.10			
cemen	ted together,	, a negativ	ve lens L12,	a negativ	e lens		4	47.22	4.30	1.67003	47.05	
L13 c	oncave towa	ard the o	biect side.	and a po	ositive		5	127.19	$d_5 =$			
				_					variable			
	cus lens L14			•		10	6	133.06	1.30	1.90265	35.76	G_2
The	numerical d	iata of th	ie respectiv	e embodi	ments	10	7	23.64	2.90			_
are sh	own in Table	es 1 to 3	below. In	each tabl	e. the		. 8	154.62	4.20	1.80518	25.36	
	ers at the lef						9	-32.48	1.10	1.80411	46.43	
		_					10	117.17	2.70			
object	side. Also, the	ne spacin	gs between	the lens g	Toups		11	-25.41	1.00	1.71300	53.97	
at a m	aximum phot	tographin	ig magnifica	tion $\beta = 0$	-0.25		12	30.77	2.80	1.86074	23.00	
	licated in the	_	—	•			13		_	1.00074	25.00	
	·	•			_		13	483.93	$d_{13} =$			
Abbe	numbers are	the value	s for d-line	$(\lambda = 587.6)$	nm).		1.4	406 70	variable	1.51.600	(4.10	~
		TADI	TE 1				14	-486.79	2.50	1.51680	64.12	G ₃
		TABI	C. 1		<u> براد نوستان د نام المسال کا نام المسال</u>		15	-39.43	0.10			
		(First embe	odiment)				16	36.24	4.50	1.51860	70.08	
	Fo	•	$f = 35 \sim 135$				17	84.69	0.80			
		F-number:		•		20	18	-47.65	1.00	1.86074	23.00	
·							19	-121.84	$d_{19} =$			
	•	Center							variable			
		thickness					20	72.48	3.00	1.51680	64.12	G ₄
	Radius of	and	Refractive	Abbe			21	-115.65	0.10			
	curvature	spacing	index	number			22	46.78	3.90	1.62041	60.29	
No.	r	d	n	ν		25	23	107.74	7.00			
1	205.20	1.40	1.80518	25,36	G		24	89.69	2.00	1.79631	40.98	
1		•	1.80518	25,30	G_1		25	37.59	2.50	•		
2	61.29	0.20	1.63041	(0.20			26	-289.15	2.50	1.51680	64.12	
3	63.33	9.10	1.62041	60.29			27	-47.37	0.10		- · · · · · ·	
4	—135.26	0.10	1 (0000				28	93.53	6.50	1.51835	60.34	
5	37.68	4.40	1.62280	57.03		20	29	-24.61	1.30	1.78797	47.53	
6	81.61	d 6 =				30	30	43.43	1.50	1.70777	41.55	
	_	variable						-43,43				
7	97.30	1.40	1.79668	45.52	G_2			f = 36.16	; f =	193.96	$\beta = -0.25$	5
8	19.09	3.00				1	A-	1.266	2,	5.760	11.260	· · · · · · · · · · · · · · · · · · ·
9	143.43	4.50	1.80518	25.36			ds					
10	-21.80	1.00	1.79668	45.52			d13	20.067		1.686	12.036	
- 11	114.33	2.10				35	d ₁₉	17.344		1.231	7.881	
12	-23.38	0.90	1.71300	53.97					$X_2 = -17$	'.0		
13	20.65	3.5	1.79631	40.98					$X_3 = -6.6$			
14	-213.64	$d_{14} =$							$X_3/X_2 = 0$			
		variable				ı	•					
15	178.32	4.50	1.51823	58.96	G_3							
16	-20.24	0.14				40			TEA IN			
17	 19.53	1.30	1.80518	25.36		TU			TABI	LE 3		
18	32.35	0.10				'			(Third Eml	bodiment)		
19	31.39	3.00	1.50137	56.46					•	$f = 35 \sim 200$		
20	76.83	$d_{20} =$						10	van ichgen.	1 - 33~200		
				•					F-number	35~45		
	•	variable							F-number:	3.5~4.5	<u></u>	
21	22.94	variable 4.00	1.58913	61.18	G4			-,	F-number: Center	3.5~4.5	<u> </u>	· · ·.
21 22	22.94 29.08		1.58913 1.80454	61.18 39.59	G ₄	45		-		3.5~4.5		· · · ·
22	29.08	4.00 1.50			G ₄	45		Radius of	Center	3.5~4.5 Refractive	Abbe	· · · .
22 23	29.08 22.20	4.00 1.50 2.50	1.80454	39.59	G ₄	45		Radius of curvature	Center thickness and		Abbe number	
22 23 24	29.08 22.20 69.44	4.00 1.50 2.50 4.50	1.80454		G ₄	45	No.		Center thickness and spacing	Refractive index	number	
22 23 24 25	29.08 22.20 69.44 —50.24	4.00 1.50 2.50 4.50 0.20	1.80454 1.56384	39.59 60.82	G ₄	45	No.	curvature r	Center thickness and spacing d	Refractive index n	number v	
22 23 24 25 26	29.08 22.20 69.44 50.24 111.34	4.00 1.50 2.50 4.50 0.20 6.50	1.80454 1.56384 1.56384	39.59 60.82 60.82	G ₄	45	No.	curvature r 142.86	Center thickness and spacing d	Refractive index n	number <i>v</i> 25.43	G ₁
22 23 24 25 26 27	29.08 22.20 69.44 50.24 111.34 18.42	4.00 1.50 2.50 4.50 0.20	1.80454 1.56384	39.59 60.82	G ₄		No.	curvature r 142.86 51.81	Center thickness and spacing d 2.20 10.50	Refractive index n	number v	Gı
22 23 24 25 26	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668	39.59 60.82 60.82 45.52		45	No. 1 2 3	curvature r 142.86 51.81 -486.84	Center thickness and spacing d 2.20 10.50 0.15	Refractive index n 1.80518 1.51680	number v 25.43 64.12	Gı
22 23 24 25 26 27	29.08 22.20 69.44 50.24 111.34 18.42	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.56384	39.59 60.82 60.82			No. 1 2 3 4	curvature r 142.86 51.81 -486.84 54.37	Center thickness and spacing d 2.20 10.50 0.15 6.20	Refractive index n	number <i>v</i> 25.43	Gı
22 23 24 25 26 27 28	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 130.95	39.59 60.82 45.52 $\beta = -0.25$			No. 1 2 3 4 5	curvature r 142.86 51.81 -486.84	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ =	Refractive index n 1.80518 1.51680	number v 25.43 64.12	Gı
22 23 24 25 26 27 28	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 130.95	39.59 60.82 45.52 $\beta = -0.25$ 13.099			No. 1 2 3 4 5	t 142.86 51.81 -486.84 54.37 379.70	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ = variable	Refractive index n 1.80518 1.51680 1.77250	25.43 64.12 49.77	Gı
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 1.79668 5.349 1.469	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449			No. 1 2 3 4 5	curvature r 142.86 51.81 -486.84 54.37	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ =	Refractive index n 1.80518 1.51680	number v 25.43 64.12	G ₁
22 23 24 25 26 27 28	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 1.30.95 5.349 1.469 1.406	39.59 60.82 45.52 $\beta = -0.25$ 13.099		50	1 2 3 4 5	curvature 142.86 51.81 -486.84 54.37 379.70 98.77 18.10	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ = variable 1.30 5.65	Refractive index n 1.80518 1.51680 1.77250	25.43 64.12 49.77	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	$4.00 \\ 1.50 \\ 2.50 \\ 4.50 \\ 0.20 \\ 6.50 \\ 1.40$ 1.40 $X_{2} = -12.$	1.80454 1.56384 1.79668 1.79668 5.349 1.469 1.406	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449			1 2 3 4 5	curvature 142.86 51.81 -486.84 54.37 379.70	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ = variable 1.30	Refractive index n 1.80518 1.51680 1.77250	25.43 64.12 49.77	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	4.00 1.50 2.50 4.50 0.20 6.50 1.40 $X_{2} = -12$ $X_{3} = -3.2$	1.80454 1.56384 1.79668 1.409 1.469 1.406	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		50	1 2 3 4 5	curvature 142.86 51.81 -486.84 54.37 379.70 98.77 18.10	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ = variable 1.30 5.65	Refractive index n 1.80518 1.51680 1.77250	number v 25.43 64.12 49.77	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	$4.00 \\ 1.50 \\ 2.50 \\ 4.50 \\ 0.20 \\ 6.50 \\ 1.40$ 1.40 $X_{2} = -12.$	1.80454 1.56384 1.79668 1.409 1.469 1.406	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		50	1 2 3 4 5	curvature 142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ = variable 1.30 5.65 3.10	Refractive index n 1.80518 1.51680 1.77250 1.80518	25.43 64.12 49.77 25.43	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	4.00 1.50 2.50 4.50 0.20 6.50 1.40 $X_{2} = -12$ $X_{3} = -3.2$	1.80454 1.56384 1.79668 1.409 1.469 1.406	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		50	1 2 3 4 5 6 7 8 9	curvature r 142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10	Refractive index n 1.80518 1.51680 1.77250 1.80518	25.43 64.12 49.77 25.43	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	4.00 1.50 2.50 4.50 0.20 6.50 1.40 $X_{2} = -12$ $X_{3} = -3.2$	1.80454 1.56384 1.79668 1.409 1.469 1.406	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		50	1 2 3 4 5 6 7 8 9	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48	Center thickness and spacing d 2.20 10.50 0.15 6.20 d ₅ = variable 1.30 5.65 3.10 1.10 0.10	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250	25.43 64.12 49.77 25.43 49.77	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	$ 4.00 1.50 2.50 4.50 0.20 6.50 1.40 $ $ X_2 = -12. X_3 = -3.2 X_3/X_2 = 0 $	1.80454 1.56384 1.79668 1.30.95 5.349 1.469 1.406 .25 27 0.267	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		50	1 2 3 4 5 6 7 8 9 10 11	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250	25.43 64.12 49.77 25.43 49.77	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426	4.00 1.50 2.50 4.50 0.20 6.50 1.40 $X_{2} = -12$ $X_{3} = -3.2$	1.80454 1.56384 1.79668 1.30.95 5.349 1.469 1.406 .25 27 0.267	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		50	1 2 3 4 5 6 7 8 9 10 11 12	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250	25.43 64.12 49.77 25.43 49.77 25.14	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	$ 4.00 1.50 2.50 4.50 0.20 6.50 1.40 $ $ X_2 = -12. X_3 = -3.2 X_3/X_2 = 0 $	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 25 27 0.267	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		55	1 2 3 4 5 6 7 8 9 10 11 12 13	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 =	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250	25.43 64.12 49.77 25.43 49.77 25.14	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 2.25 27 0.267 LE 2 abodiment)	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		55	1 2 3 4 5 6 7 8 9 10 11 12 13	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250 1.61800	25.43 64.12 49.77 25.43 49.77 25.14 63.38	G_2
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 .25 27 0.267 D.267 LE 2 abodiment) f = 35~200	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		55	1 2 3 4 5 6 7 8 9 10 11 12 13 14	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable 2.80	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250	25.43 64.12 49.77 25.43 49.77 25.14	
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 .25 27 0.267 D.267 LE 2 abodiment) f = 35~200	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		55	1 2 3 4 5 6 7 8 9 10 11 12 13 14	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250 1.75000 1.61800 1.51680	25.43 64.12 49.77 25.43 49.77 25.14 63.38	G_2
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	4.00 1.50 2.50 4.50 0.20 6.50 1.40 TABI Second Employed length: for the call length: for	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 .25 27 0.267 D.267 LE 2 abodiment) f = 35~200	39.59 60.82 45.52 $\beta = -0.25$ 13.099 10.449		55	1 2 3 4 5 6 7 8 9 10 11 12 13 14	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94 304.15 -52.50 48.14	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable 2.80 0.15 4.80	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250 1.61800	25.43 64.12 49.77 25.43 49.77 25.14 63.38	G_2
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	4.00 1.50 2.50 4.50 0.20 6.50 1.40	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 .25 27 0.267 LE 2 abodiment) f = 35~200 3.5~4.5	$ \begin{array}{r} 39.59 \\ 60.82 \\ 45.52 \\ \beta = -0.25 \\ 13.099 \\ 10.449 \\ 14.676 \end{array} $		50	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	r 142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94 304.15 -52.50 48.14 -44.60	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable 2.80 0.15 4.80 0.50	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.75000 1.61800 1.51680 1.51680	25.43 64.12 49.77 25.43 49.77 25.14 63.38 64.12	G_2
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762 For	4.00 1.50 2.50 4.50 0.20 6.50 1.40 TABI Second Emeral length: 1 F-number: Center thickness and	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 25 27 0.267 LE 2 abodiment) f = 35~200 3.5~4.5 Refractive	39.59 60.82 45.52 $\beta = -0.23$ 13.099 10.449 14.676 Abbe		55	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94 304.15 -52.50 48.14 -44.60 -39.18	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable 2.80 0.15 4.80 0.50 1.10	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.80518 1.77250 1.75000 1.61800 1.51680	25.43 64.12 49.77 25.43 49.77 25.14 63.38	G ₂
22 23 24 25 26 27 28 —————————————————————————————————	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762	4.00 1.50 2.50 4.50 0.20 6.50 1.40 TABI Second Em Cal length: f F-number: Center thickness and spacing	1.80454 1.56384 1.56384 1.79668 130.95 5.349 1.469 1.406 25 27 0.267 LE 2 abodiment) f = 35~200 3.5~4.5 Refractive index	39.59 60.82 60.82 45.52 $\beta = -0.23$ 13.099 10.449 14.676 Abbe number		50	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	r 142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94 304.15 -52.50 48.14 -44.60	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable 2.80 0.15 4.80 0.50 1.10 d20 =	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.75000 1.61800 1.51680 1.51680	25.43 64.12 49.77 25.43 49.77 25.14 63.38 64.12	G ₂
22 23 24 25 26 27 28 d ₆ d ₁₄	29.08 22.20 69.44 -50.24 111.34 -18.42 -438.94 f = 36.16 1.090 17.426 19.762 For	4.00 1.50 2.50 4.50 0.20 6.50 1.40 TABI Second Emeral length: 1 F-number: Center thickness and	1.80454 1.56384 1.79668 130.95 5.349 1.469 1.406 25 27 0.267 LE 2 abodiment) f = 35~200 3.5~4.5 Refractive	39.59 60.82 45.52 $\beta = -0.23$ 13.099 10.449 14.676 Abbe		50	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	142.86 51.81 -486.84 54.37 379.70 98.77 18.10 -74.41 -23.75 58.48 32.19 219.20 -25.10 -55.94 304.15 -52.50 48.14 -44.60 -39.18	Center thickness and spacing d 2.20 10.50 0.15 6.20 d5 = variable 1.30 5.65 3.10 1.10 0.10 2.70 3.00 1.10 d14 = variable 2.80 0.15 4.80 0.50 1.10	Refractive index n 1.80518 1.51680 1.77250 1.80518 1.77250 1.75000 1.61800 1.51680 1.51680	25.43 64.12 49.77 25.43 49.77 25.14 63.38 64.12	G ₂

TABLE 3-continued

	Foc		bodiment) f = 35~200 : 3.5~4.5		
23	-59.50	6.68			
24	—73.85	5.58	1.85026	32.24	
25	24.04	2.35		-	
26	— 189.79	2.50	1.51680	64.12	
27	—35.72	0.15			
28	30.69	3.50	1.54072	47.22	
29	472.93				
	f = 36.16	f =	<u> 195.09</u>	$\beta = -0.25$	
d ₅	0.800	3:	3.801	19.401	
d ₁₄	26.423		1.000	16.360	
d ₂₀	11.300		3.722	0.762	
		$\zeta_2 = -12$			
		$\zeta_3 = 2.96$ $\zeta_2/X_3 = -\frac{1}{2}$			

In order to show the improvement in the imaging performance of each of the above-described embodi- 20 ments during macro-photography, a case where macrophotography has been effected by only the second lens group G2 will be shown as a comparative example. FIGS. 5A-5D show the various aberrations in the first embodiment. FIG. 5A shows the aberrations at the 25 wide angle end, and FIG. 5B shows the aberrations at the telephoto end. FIG. 5C shows the aberrations when macro-photography has been effected by movement of only the second lens group G2, and more particularly the aberrations when macro-photography at a photo- 30 graphing distance Do=0.255 m and a photographing magnification $\beta = -0.25$ has been effected with the second lens group G2 moved by 8.37 mm toward the object side. FIG. 5D shows the aberrations when macro-photography at a photographing distance Do = 0.288 35 m and a photographing magnification $\beta = -0.25$ has been effected by the macro-photography system according to the present invention with the second lens group G2 moved by 12.25 mm toward the object side and the third lens group G3 moved by 3.27 mm also 40 toward the object side. From the comparison with the aberrations shown in FIG. 5C, it is apparent that in FIG. 5D, astigmatism is corrected very well and at the same time, coma is also corrected well.

FIG. 6A shows the aberrations at the wide angle end, 45 and FIG. 6B shows the aberrations at the telephoto end. FIG. 6C shows the aberrations when macro-photography has been effected by movement of only the second lens group G2, and more particularly the aberrations when macro-photography at a photographing distance 50 Do=0.364 m and a photography magnification $\beta = -0.25$ has been effected with the second lens group G2 moved by 8.52 mm toward the object side. FIG. 6D shows the aberrations when macro-photography at a photographing distance Do=0.314 m and a photo- 55 graphing magnification $\beta = -0.25$ has been effected by the macro-photography system according to the present invention with the second lens group G2 moved by 13.0 mm toward the object side and the third lens group G3 moved by 3.78 mm also toward the object side. 60 FIG. 6E shows the aberrations when macro-photography at a photographing distance Do=0.244 mm and a photographing magnification $\beta = -0.25$ has been effected with the second lens group G2 moved by 17.0 mm toward the object side, the third lens group G3 65 moved by 6.65 mm toward the object side and the first lens group G1 moved by 7.5 mm toward the image side. According to the comparison between these aberration

graphs, it is apparent that astigmatism and coma occurring as shown in FIG. 6C in the case by the movement of only the second lens group G2 are corrected considerably well as shown in FIG. 6D by adding the movement of the third lens group G3 in accordance with the present invention. It is apparent that if the first lens group G1 is also moved at the same time, coma will be corrected better as shown in FIG. 6E.

FIG. 7A shows the aberrations at the wide angle end, and FIG. 7B shows the aberrations at the telephoto end. FIG. 7C shows the aberrations when macro-photography has been effected by movement of only the second lens group G2, and more particularly the aberrations when macro-photography at a photographing distance Do=0.270 m and a photographing magnification $\beta = -0.25$ has been effected with the second lens group G2 moved by 15.37 mm toward the object side. FIG. 7D shows the aberrations when macro-photography at a photographing distance Do=0.316 m and a photographing magnification $\beta = -0.25$ has been effected by the macro-photography system according to the present invention with the second lens group G2 moved by 10.5 mm toward the object side and the third lens group G3 moved by 4.04 mm toward the image side. FIG. 7E shows the aberrations when macro-photography at a photographing distance Do=0.280 m and a photographing magnification $\beta = -0.25$ has been effected with the second lens group G2 moved by 12.4 mm toward the object side, the third lens group G3 moved by 2.96 mm toward the image side and further the first lens group G1 moved by 2.0 mm toward the image side. According to the comparison between these aberration graphs, it is apparent that astigmatism and coma substantially occurring as shown in FIG. 7C in the case by the movement of only the second lens group G2 are corrected considerably well as shown in FIG. 7D by adding the movement of the third lens group G3 in accordance with the present invention. It is apparent that if the first lens group G1 is also moved at the same time, coma will be corrected better as shown in FIG. 7E. The broken line in the spherical aberration graph of each aberration graph indicates the offence of the sine condition.

According to the present invention, as described above, there is achieved a zoom lens which is capable of photographing up to a very short photographing distance Do of 0.3 m or less and moreover in which astigmatism, coma, etc. are corrected well even during macro-photography and which can maintain an excellent imaging performance.

What we claim is:

1. A zoom lens capable of macrophotography and having, in succession from the object side, a first lens group of positive refractive power, a second lens group of negative refractive power, a third lens group of positive refractive power and a fourth lens group of positive refractive power, said first lens group, said third lens group and said fourth lens group being movable toward the object side for a magnification change from the wide angle end to the telephoto end, wherein the focusing up to a short distance object is made possible by moving said second lens group along the optic axis from the position of its telephoto end toward the object side and moving said third lens group along the optic axis from the position of its telephoto end and the following condition is satisfied:

-continued

where χ_2 is the amount of movement of said second lens group from the telephoto end toward the object side for short distance focusing and χ_3 is the amount of movement of said third lens group from the telephoto end toward the object side for short distance focusing.

- 2. A zoom lens according to claim 1, wherein said first lens group is moved along the optic axis during the movement of said second and third lens groups for the 10 focusing to the short distance object.
- 3. A zoom lens according to claim 1, satisfying the following data:

	· · · · · · · · · · · · · · · · · · ·	F-number:	3.3~7.3		
		Center thickness	-		
	Radius of	and	Refractive	Abbe	
	curvature	spacing	index	number	
٧o.	r	d	n	V	اختا ببط اور ناز الإنسا
1.	205.20	1.40	1.80518	25.36	G_1
2	61.29	0.20			
3	63.33	9.10	1.62041	60.29	
4	-135.26	0.10	•		
5	37.68	4.40	1.62280	57.03	
6	81.61	$d_6 =$			
		variable			
7	97.30	1.40	1.79668	45.52	G_2
8	19.09	3.00	_		-
9	143.43	4.50	1.80518	25.36	
10	-21.80	1.00	1.79668	45.52	
11	114.33	2.10	1117000	17.52	
12	-23.38	0.90	1.71300	·53.97	
13	20.65	3.5	1.79631	40.98	
		_	1.79031	40.70	
14	-213.64	$d_{14} =$			
1.0	150.20	variable	1 51000	50.0 C	
15	178.32	4.50	1.51823	58.96	G ₃
16	-20.24	0.14			
17	-19.53	1.30	1.80518	25.36	
18	-32.35	0.10			
19	31.39	3.00	1.50137	56.46	
20	76.83	$d_{20} =$			
		variable			
21	22.94	4.00	1.58913	61.18	G ₄
22	29.08	1.50	1.80454	39.59	
23	22.20	2.50			
24	69.44	4.50	1.56384	60.82	
25	-50.24	0.20			
26	111.34	6.50	1.56384	60.82	
27	-18.42	1.40	1.79668	45.52	
28	-438.94		·.		
	f = 36.16	f =	130.95	$\beta = -0.25$	
d ₆	1.090	2:	5.349	13.099	
d ₁₄	17.426		1.469	10.449	
d ₂₀	19.762		1.406	14.676	

4. A zoom lens according to claim 1, satisfying the following data:

 $X_3/X_2 = 0.267$

Focal length: $f = 35 \sim 200$ F-number: $3.5 \sim 4.5$						
No.	Radius of curvature	Center thickness and spacing d	Refractive index n	Abbe number v		
1	158.96	1.50	1.80518	25.36	G ₁	_
· 2 3	64.18 — 138.79	8.00 0.10	1.49782	82.28		
4	47.22	4.30	1.67003	47.05		

	Focal length: $f = 35 \sim 200$ F-number: $3.5 \sim 4.5$					
5	127.19	d ₅ =	•			
		variable				
6	133.06	1.30	1.90265	35.76	G_2	
7	23.64	2.90				
8	154.62	4.20	1.80518	25.36		
9	-32.48	1.10	1.80411	46.43		
10	117.17	2.70				
11	-25.41	1.00	1.71300	53.97		
12	30.77	2.80	1.86074	23.00		
13	483.93	$d_{13} =$				
		variable				
14	-486.79	2.50	1.51680	64.12	G ₃	
15	-39.43	0.10				
16	36.24	4.50	1.51860	70.08		
17	-84.69	0.80				
18	47.65	1.00	1.86074	23.00		

30	-43.43				
/				,,,,,	
29	-24.61	1.30	1.78797	47.53	
28	93.53	6.50	1.51835	60.34	
27	-47.37	0.10			
26	—289.15	2.50	1.51680	64.12	
25	37.59	2.50			
24	 89.69	2.00	1.79631	40.98	
23	107.74	7.00			
22	46.78	3.90	1.62041	60.29	
21	—115.65	0.10			
20	72.48	3.00	1.51680	64.12	G_4
		variable			
	21 22 23 24 25 26 27 28	20 72.48 21 -115.65 22 46.78 23 107.74 24 -89.69 25 37.59 26 -289.15 27 -47.37 28 93.53	21 -115.65 0.10 22 46.78 3.90 23 107.74 7.00 24 -89.69 2.00 25 37.59 2.50 26 -289.15 2.50 27 -47.37 0.10 28 93.53 6.50	20 72.48 3.00 1.51680 21 -115.65 0.10 22 46.78 3.90 1.62041 23 107.74 7.00 24 -89.69 2.00 1.79631 25 37.59 2.50 26 -289.15 2.50 1.51680 27 -47.37 0.10 28 93.53 6.50 1.51835	20 72.48 3.00 1.51680 64.12 21 -115.65 0.10

 $d_{19} =$

	f = 36.16	f = 193.96	$\beta = -0.25$
d ₅	1.266	35.760	11.260
d ₁₃	20.067	1.686	12.036
d ₁₉	17.344	1.231	7.881
	X ₂	= -17.0	·

 $X_3 = -6.65$ $X_3/X_2 = 0.391$

-121.84

5. A zoom lens according to claim 1, satisfying the following data:

0		Fo	ocal length: F F-number:			
5	NT.	Radius of curvature	Center thickness and spacing	Refractive index	Abbe number	
•	No.	<u> </u>	d	n	ν	
	1	142.86	2.20	1.80518	25.43	G_1
	2	51.81	10.50	1.51680	64.12	
	3	-486.84	0.15			
	4	54.37	6.20	1.77250	49.77	
0	5	379.70	d5 = variable		•	
	6	98.77	1.30	1.77250	49.77	G_2
	7	18.10	5.65			_
	8	74.41	3.10	1.80518	25.43	
	9	-23.75	1.10	1.77250	49.77	
	10	58.48	0.10			
5	11	32.19	2.70	1.75000	25.14	
	12	219.20	3.00			
	13	-25.10	1.10	1.61800	63.38	
	14	55.94	d ₁₄ == variable			

2.80

4.80

0.50

1.10

 $d_{20} =$

variable

7.00

1.20

6.68

5.58

2.35

1.51680

1.51680

1.80518

1.60342

1.85000

1.85026

64.12

64.12

25.43

38.02

40.51

32.24

 G_3

 G_4

304.15

48.14

-44.60

-39.18

-758.83

29.51

-33.05

-59.50

-73.85

24.04

		-conti	nued		
	Foo	cal length:	F = 35~200 3.5~4.5		5
26	— 189.79	2.50	1.51680	64.12	
27	-35.72	0.15	•		
28	30.69	3.50	1.54072	47.22	
29	472.93	·	····	······································	10
·	f = 36.16	f =	195.09	$\beta = -0.25$	
d ₅	0.800	33	3.801	19.401	
d ₁₄	26.423	:	1.000	16.360	
d ₂₀	11.300	3	3.722	0.762	15

 -continued	
 Focal length: F = 35~200 F-number: 3.5~4.5	
$X_2 = -12.4$ $X_3 = 2.96$ $X_2/X_3 = -0.239$	

6. A zoom lens according to claim 1, wherein said third lens group is moved toward the object side for the focusing to the short distance object.

7. A zoom lens according to claim 6, wherein said first lens group is moved along the optic axis during the movement of said second and third lens groups for the focusing to the short distance object.